LIGHT SOURCE UNIT AND REFLECTING MIRROR

BACKGROUND OF THE INVENTION

(1) Technical Field

The present invention relates to a light source unit including a high-pressure discharge lamp and a reflecting mirror used therefor.

(2) Background Art

A high-pressure discharge lamp such as a metal halide lamp and a high-pressure mercury lamp is employed as a light source for a light source unit for an image projecting apparatus (hereinafter, referred to as a light source unit) such as a liquid crystal projector and a digital micromirror device (DMD) projector. In order to make use of visible radiation radiated from this kind of high-pressure discharge lamp as effectively as possible, the light source unit is typically constructed to provide a paraboloid or ellipsoid reflecting mirror outside a luminous bulb of the high-pressure discharge lamp to surround the luminous bulb.

In recent years, this type of light source unit has become small. The downsized light source unit is significantly affected by heat from the luminous bulb of its high-pressure discharge lamp. Therefore, the luminous bulb may be devitrified to decrease the light output, or an external lead and a metal foil may be oxidized in a sealing portion of the high-pressure discharge lamp, leading to the luminous bulb leakage. In addition, when the temperature of the coldest portion of the luminous bulb becomes very high, this sometimes allows the spectral power distribution to change, leading to deteriorated color characteristics. Furthermore, when the temperature of the reflecting mirror becomes very high, a multilayer film evaporated onto the reflecting mirror may come off. In order to prevent various thermal problems from being caused by increase in the temperature of the inside of the light source unit as described above, some measures have been taken until now and have been disclosed.

A known method for preventing the thermal problems in the light source unit is one in which a high-pressure discharge lamp or a reflecting mirror is cooled by using convection. More specifically, the way of cooling is classified into cooling by a flow of the air that is aspirated from an opening located in the vicinity of the front of a concave reflecting mirror into the reflecting mirror, flows through the inside of the reflecting mirror and then is released from an opening formed in a neck portion of the reflecting mirror, as disclosed in Japanese Laid-Open Publication No. 2001-307535, and cooling by a flow of the air in the opposite direction.

However, the known light source unit disclosed in Japanese Laid-Open Publication No. 2001-307535 must comprise, in addition to a discharge lamp and a reflecting mirror, a base component for holding the discharge lamp in the neck portion to form an opening serving as an air passage in the neck portion. This is undesirable because the number of components increases so that the cost increases.

Furthermore, a large amount of cement is used to fix the discharge lamp to the reflecting mirror. The present inventors found the following problem: when the base component is attached to the neck portion, the stray capacitance in the vicinity of the neck portion increases due to this cement and the base component, and thus a start pulse is not effectively applied to the discharge lamp at the start of the discharge lamp so that it becomes hard to start the discharge lamp. The present inventors are the first finders of this problem.

SUMMARY OF THE INVENTION

It is an object of the present invention to provide a light source unit that can cool a high-pressure discharge lamp and a reflecting mirror without including a base component and ensures good start characteristics of the high-pressure discharge lamp, and a reflecting mirror used therefor.

A light source unit of the present invention comprises: a double-ended high-pressure

discharge lamp including a luminous bulb into which a luminous material is encapsulated and first and second sealing portions respectively extending from both ends of the luminous bulb; and a reflecting mirror for reflecting light emitted from the high-pressure discharge lamp, wherein the reflecting mirror comprises a reflecting portion for reflecting the light, a wide opening provided toward the direction in which the light outgoes, and a neck portion in which a narrow opening is provided to fix the high-pressure discharge lamp, said reflecting portion and said neck portion being formed as one unit, the first sealing portion of the high-pressure discharge lamp is inserted into the narrow opening of the reflecting mirror and fixed to the neck portion, and at least one air hole communicating with the narrow opening is provided in the neck portion.

In one preferred embodiment, one or more air holes are provided in the neck portion, and all of said one or more air holes are placed vertically below the lamp when viewed with the lamp turned on in a horizontal position.

In one embodiment, said at least one air hole is a slit or a circular hole.

In one embodiment, a front glass is provided over the wide opening.

A reflecting mirror of the present invention for reflecting light emitted from a high-pressure discharge lamp, comprises: a reflecting portion for reflecting the light; a wide opening provided toward the direction in which the light outgoes; and a neck portion in which a narrow opening is provided to fix the high-pressure discharge lamp, said reflecting portion and said neck portion being formed as one unit, wherein at least one air hole communicating with the narrow opening is provided in the neck portion.

According to the present invention, there can be provided a light source unit and reflecting mirror which have the following effects: since at least one air hole is provided in a neck portion of a reflecting mirror used for a light source unit, a high-pressure discharge lamp and the reflecting mirror can be cooled without providing a separate member, and since an increase in the stray capacitance caused by using a separate member does not occur, good start characteristics of the high-pressure discharge lamp are ensured.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure **1A** is a schematic view showing a light source unit according to a first embodiment viewed from a neck portion side thereof; and Figure **1B** is a cross sectional view taken along the line A-A shown in Figure **1A**.

Figure **2A** is a schematic view showing a light source unit according to a second embodiment viewed from a neck portion side thereof; Figure **2B** is a schematic diagram viewed from the **B** direction; and Figure **2C** is a cross sectional view taken along the line B-B shown in Figure **2A**.

Figure **3** is a schematic cross sectional view showing a light source unit according to a third embodiment.

DETAILED DESCRIPTION OF THE INVENTION

Embodiments of the present invention will be described hereinafter with reference to the drawings. For the sake of simplicity, the same reference numerals are given to the components having substantially the same functions. The present invention is not limited to the following embodiments.

(Embodiment 1)

Figure **1** is a view showing a light source unit **1000** according to a first embodiment of the present invention. Figure **1A** is a schematic view showing a light source unit **1000** viewed from a neck portion **122** side; and Figure **1B** is a cross sectional view taken along the line A-A shown in Figure **1A**.

The light source unit **1000** of this embodiment comprises a high-pressure discharge lamp **1100** and a reflecting mirror **1200** for reflecting light emitted from this high-pressure discharge lamp **1100**.

The high-pressure discharge lamp **1100** is a so-called double-ended discharge lamp composed of a luminous bulb **100** made of quartz and first and second sealing portions

102a and **102b** made of quartz and extending from the luminous bulb **100**. The luminous bulb **100** is hollow and has an internal diameter of 5mm and a capacity of 0.08cc, and the whole length thereof including the lengths of the two sealing portions **102a** and **102b** is 55mm. The sealing portions **102a** and **102b** are generally cylindrical. 16mg mercury and argon having a pressure of 20kPa (both not shown) are encapsulated as a luminous material in the luminous bulb **100**. Therefore, this high-pressure discharge lamp **1100** is a high-pressure mercury lamp.

A pair of electrodes **104a** and **104b** are provided in the high-pressure discharge lamp **1100** so as to be located inside the luminous bulb **100**. The distance between the tips of the electrodes is 1.0mm. Ends of the pair of electrodes **104a** and **104b** opposite to the tips thereof located in the luminous bulb **100** are electrically connected to one ends of metal foils **106a** and **106b** made of molybdenum, respectively, and the other ends of the metal foils **106a** and **106b** are electrically connected to external leads **108a** and **108b**, respectively. Parts of the electrodes **104a** and **104b**, the metal foils **106a** and **106b** and parts of the external leads **108a** and **108b** are buried in the sealing portions **102a** and **102b**, respectively, and are sealed up using quartz. The external lead **108a** extending from the second sealing portion **102a** placed toward a wide opening **124** of a reflecting mirror **1200** is electrically connected to a lead **110**. The lead **110** is drawn out through a through-hole **128** provided in the reflecting mirror **1200** to the outside of the reflecting mirror **1200**.

The reflecting mirror **1200** comprises a reflecting portion **120** for reflecting light from the high-pressure discharge lamp **1100**, a wide opening **124** provided toward the direction in which the light outgoes, and a neck portion **122** in which a narrow opening **125** is provided to fix the high-pressure discharge lamp **1100**. The reflecting mirror **1200** is made of borosilicate glass having a wall thickness of 5mm. The reflecting portion **120** and the neck portion **122** are successively formed of borosilicate glass, i.e., they are formed as one unit. The diameter of the wide opening **124** of the reflecting portion **120** is 45mm, and the internal surface of the reflecting portion **120** is given a multi-level evaporated film

made of titanium oxide (TiO_2) and silicon oxide (SiO_2). The shape of the reflecting portion **120** is appropriately selected from a paraboloid of revolution or an ellipsoid of revolution, depending on how to utilize light emitted from the opening **124** of the reflecting portion **120**. The neck portion **122** is cylindrical, and a hollow portion thereof is herein also referred to as the narrow opening **125**. A front glass **150** is provided on the wide opening **124**. Since the front glass **150** is provided, in the case where the luminous bulb **100** is broken, broken pieces of the luminous bulb **100** can be restrained from flying out of the light source unit **1000**. In particular, when the operating pressure of sealed-in materials in the luminous bulb **100** at lighting is 100 or more atmospheres, the front glass **150** is highly effective in preventing the broken pieces thereof from flying out.

In order to fix the high-pressure discharge lamp **1100** to the reflecting mirror **1200**, the first sealing portion **102b** is inserted into the narrow opening **125** of the neck portion **122**. Here, the diameter of the first sealing portion **102b** is smaller than the internal diameter of the narrow opening **125**, and thus a gap is produced between the first sealing portion **102b** and the internal wall of the narrow opening **125**. Therefore, cement **130** is poured into this gap, thereby fixing the high-pressure discharge lamp **1100** to the reflecting mirror **1200**.

Two air holes **126** and **126** passes through the neck portion **122** around the center of the neck hole in the running direction, and the cement is poured into the back end of the neck portion **122** to the extent that these air holes **126** and **126** are not filled in. These air holes **126** and **126** are slits, the lengths thereof along the **A** direction shown in Figure **1B** are each 5mm, and the widths thereof orthogonal to the **A** direction are each 3mm. The air holes **126** and **126** are provided in upward and downward directions as shown in Figure **1B**, respectively. The "air holes" are provided by directly working on the neck portion **122** but are not composed of the other members. That is, according to this embodiment, unlike the case that a member different from the neck portion **122** is attached to the neck portion **122** to provide holes through which the air passes in the neck portion **122** as

disclosed in Japanese Laid-Open Publication No. 2001-307535, holes through which the air passes are formed in the neck portion **122** itself that is a part of the reflecting mirror.

Hereinafter, a description will be given of a thermal action at the time that the light source unit **1000** of this embodiment is operated.

When the high-pressure discharge lamp **1100** of the light source unit **1000** becomes in a steady operating state, the temperature around the luminous bulb **100**, especially the temperature of the top surface of the luminous bulb **100**, becomes highest, and the temperatures of the top surface of the reflecting mirror **1200** and sealing portions **102a** and **102b** become second highest. In this case, since the air holes **126** and **126** that are slits are provided in the neck portion **122**, the cold air comes from the outside of the reflecting mirror **1200** through the air holes **126** and **126** into the reflecting mirror **1200**, and the high-temperature air in the reflecting mirror **1200**, especially around the luminous bulb, is released through the through-hole **128** provided in the top surface of the reflecting mirror to the outside of the reflecting mirror **1200**.

It has been shown that the structure of this embodiment allows the air holes **126** provided in the neck portion **122** to be realized with a simple structure without providing a separate member and allows the above-mentioned various problems due to high temperature to be prevented by effectively cooling the inside of the reflecting mirror **1200** like air holes formed of a separate member in the known art.

Further surprisingly, it has been found that the absence of a separate member in the neck portion **122** improves the start characteristics of the light source unit **1000** of this embodiment. This will be described hereinafter.

When a separate member is attached to the neck portion **122** to provide holes through which the air passes (the separate member means one formed to cover the neck portion **122**, such as a ceramic vessel through which air holes pass), there may be a case where the light source unit **1000** does not start three times every 100 times even with a pulse voltage of 18kV being applied. On the other hand, when no separate member is

provided, it normally starts and is turned on at all of one hundred start tests in which a pulse voltage of 10 through 15kV lower than 18kV is applied. This reason is considered as follows: the presence of the separate member allows the space between the member and the sealing portion **102b** of the lamp to become a pseudo-capacitor, through which the pulse voltage leaks so that the voltage between the electrodes **104a** and **104b** decays. On the other hand, it is considered that in the case of this embodiment including the neck portion **122** in which a separate member is not provided, the capacitance of the pseudo-capacitor becomes small and the decay of the pulse voltage is relatively small, resulting in the light source unit certainly starting even at a low pulse voltage. That is, as compared with the case where air holes are provided using a separate member, in the case where the air holes **126** are directly formed in the neck portion **122** that is a part of the reflecting mirror **1200** without using a separate member, the high-pressure discharge lamp can be more certainly started even when the pulse voltage at start becomes lower.

As described so far, since the air holes **126** are provided in the neck portion **122** of the reflecting mirror **1200** used for the light source unit, this provides the light source unit **1000** in which the high-pressure discharge lamp **1100** and the reflecting mirror **1200** can be effectively cooled without providing a separate member and good start characteristics of the high-pressure discharge lamp **1100** can be ensured, and provides the reflecting mirror **1200** used therefor.

Although in this first embodiment the number of the air holes is two, this is merely an example and the number of air holes is not limited to this number. For example, the number of the air holes may be three, four or more as long as the strength with which the high-pressure discharge lamp **1100** is held without being detached or wobbling is kept when the first sealing portion **102b** of the high-pressure discharge lamp **1100** is fixed to the neck portion **122** of the reflecting mirror **1200**.

Furthermore, the length and width of each of the air holes **126** are also not restrictive to the length and width thereof in the first embodiment as long as the strength with which

the high-pressure discharge lamp **1100** is held is ensured enough. Although the shape of each of the air holes **126** is a slit, it is not particularly limited, and similar effects can be obtained as long as each of the air holes **126** has a sufficient size to admit the outside air enough to cool the high-pressure discharge lamp **100**. Each of the air holes **126** preferably has a circular shape appeared in the opening surface because in this case, drilling is easy.

Furthermore, in order to more effectively cool the light source unit **1000**, air holes may be provided in the reflecting portion **120** of the reflecting mirror **1200**. In this case, the size of each of the air holes is preferably small such that the amount of the outgoing light is not decreased. However, light source units have different optimum sizes, shapes and locations of each of air holes because of differences in cooling efficiency. The air holes are preferably provided in the upper part of the reflecting portion **120** because the cooling efficiency becomes better.

In addition, although in the first embodiment a high-pressure mercury lamp is employed, other metal lamps such as a metal halide lamp, a xenon lamp and a halogen lamp including filaments may be employed.

(Embodiment 2)

Figure **2** shows another embodiment of a light source unit according to the present invention. Figure **2A** is a schematic view of a light source unit **1001** viewed from a neck portion **122** side. Figure **2B** is a schematic view thereof viewed from the **B** direction shown in Figure **2A**, and Figure **2C** is a cross sectional view taken along the line B-B shown in Figure **2A**. Figure **2B** does not show projections **300** but shows only air holes **126** to help the understanding of this drawing.

This embodiment is different from the first embodiment in that projections **300** are formed on a first sealing portion **102b** and that air holes **126** extend to the back end of a neck portion **122**, i.e., they are incisions extending from the back end of the neck portion **122** in the direction in which light outgoes. However, the other components are the same

as those of the first embodiment. Here, the back end of the neck portion **122** represents one end of the neck portion **122** opposite to the other end thereof connected to a reflecting portion **120**.

Plate-shaped projections **300** made of quartz are formed on a first sealing portion **102b** of a high-pressure discharge lamp **1101** to project from a generally cylindrical body of the first sealing portion **102b**. These projections **300** are formed by pressing the sealing portion **102b** using a mold or the like while the sealing portion **102b** is still soft in sealing. In addition, there can be provided, as another projection forming method, a method in which the projections **300** are formed by cutting the first sealing portion **102b** using a carbon dioxide gas laser. Each of the projections **300** is not limited to the plate-shaped one but it may be a rod-shaped one or a convex one in which the edges of the rod-shape one are rounded. The high-pressure discharge lamp **1101** is inserted from the neck portion **122** toward a wide opening **124**. The projections **300** are placed to fit into U-shaped air holes **126** that are provided in the neck portion **122** of the reflecting mirror **1201** to extend to one end of the neck portion **122** opposite to the wide opening **124**. These projections **300** are placed in the location which ensures that the air holes **126** have a sufficient size to admit the outside air enough to cool the high-pressure discharge lamp **1101**.

According to this embodiment, there can be provided the light source unit **1001** and the reflecting mirror **1201** which have the following effects: since the high-pressure discharge lamp **1101** is fixed to the neck portion **122** by the projections **300**, the mounting strength between the high-pressure discharge lamp **1101** and the reflecting mirror **1201** can be improved; and since the air holes **126** are further provided in the neck portion **122**, the high-pressure discharge lamp **1101** and the reflecting mirror **1201** can be cooled without providing a separate member, and the stray capacitance resulting from the separate member can be reduced to ensure the start characteristics of the high-pressure discharge lamp **1101**. In addition, since the fixing can be carried out without using the cement **130**,

the number of process steps is decreased, resulting in cost reduction. Cement may be used to further increase fixing strength.

(Embodiment 3)

A light source unit **1002** of this embodiment shown in Figure **3** is different from that of the first embodiment in that only one air hole **126** is provided in a neck portion **122** of a reflecting mirror **1202** and that a front glass is not provided. The air hole **126** in this embodiment is provided below a first sealing portion **102b** when viewed with the first sealing portion **102** in a horizontal position. If the air hole **126** is provided in this manner, the cold air flows from the outside of the reflecting mirror **1202** through the air hole **126** into the reflecting mirror **1202**, the cold air is mixed with the high-temperature air within the reflecting mirror **1202**, particularly around a luminous bulb **100**, and the mixed air is released from a wide opening **124** at the front of the reflecting mirror **1202** to the outside of the reflecting mirror **1202**. Since the front glass is not provided, the air flows smoothly, resulting in an improved cooling efficiency. Furthermore, since a single air hole **126** is provided in the lower part of the neck portion **122** and no air hole exists in the upper part of the neck portion **122**, there does not occur a situation in which the cold air flowing from the outside of a reflecting mirror **1202** through the air hole **126** into the inside thereof immediately escapes from the upper air hole so that the cold air hardly contributes to the cooling of a light source unit.

Although in this embodiment a single air hole **126** is provided in the neck portion **122**, plural air holes may be provided. In this case, the air holes **126** are placed in the bottom side of the neck portion **122** when viewed with the high-pressure discharge lamp **1102** in a horizontal position turned on. In the case of putting the light source unit **1002** of this embodiment into practical use, the high-pressure discharge lamp **1102** is placed in a horizontal position, and the upper and lower sides of the reflecting mirror **1202** are fixed. Therefore, the air holes **126** can easily be placed in the bottom side of the neck portion **122**. In other words, the air holes **126** are provided only in the vicinity of a single predetermined

line **180** that is parallel to the direction of extension of the first sealing portion **102b** and passes through the inside of the neck portion **122**. The single predetermined line **180** represents a line that passes through the lowest part of the neck portion **122** and is parallel to the direction in which the first sealing portion **102b** extends, and providing the air holes **126** only in the vicinity thereof means that the air holes **126** are provided only in the lower side of the neck portion **122** when viewed with the first sealing portion **102b** in a horizontal position.

If the air holes **126** are provided in this manner, convection allows the outside air to easily flow through the air holes **126** into the inside of a light source unit **1000**. Thus, cooling can effectively be carried out. Also in the case of this embodiment (a single air hole **126** is provided), it can be said that the air hole **126** is provided only in the vicinity of the predetermined line **180** that is parallel to the direction of extension of the first sealing portion **102b** and passes through the inside of the neck portion **122**.

Cement **130** is used to fix the high-pressure discharge lamp **1102** to the reflecting mirror **1202**. In this case, there is a possibility that a small amount of cement **130** may flow before the cement **130** sets so that the air hole **126** is partly blocked. However, in this embodiment, when the cement **130** is used for fixing, the cement **130** is set with the air hole **126** being directed upward, i.e., with the position shown in Figure **3** being turned upside down, whereby the cement **130** does not flow into the air hole **126** and the air hole **126** is not blocked.

Even when a front glass is provided over the opening **124**, a cooling effect can be obtained because the air flows out through an through-hole **128** or air holes provided in the reflecting surface of the reflecting mirror **1202**.

In any one of the above-described first through third embodiments, it is needless to say that when a fan for forcibly ventilating the light source unit to the outside thereof is further provided, an improved cooling effect is obtained.

The entire content of JP 2002-328049 is incorporated herein by reference.